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Montana Department of Health
and Environmental Sciences

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OCCUPATIONAL EXPOSURE TO NITROUS OXIDE IN MONTANA DENTAL OFFICES

Nationwide more than 100,000 workers are exposed to nitrous oxide in dental offices. Data collected in other states show that dental workers are exposed to nitrous oxide levels several times higher than workers in hospital operating rooms. Furthermore, a large scale epidemiologic study by Ellis N. Cohen, et.al.[1] reported significant occupational health problems associated with nitrous oxide exposures in dental offices.

Because of the potentially serious health problems that can result from exposure to nitrous oxide and the high occupational nitrous oxide exposures reported in other states, the Occupational Health Bureau, Montana Department of Health and Environmental Sciences (DHES) initiated an investigation of occupational exposures to nitrous oxide in Montana.

A total of 355 Montana dentists were contacted. Of these, 172 or 48 percent, indicated they use nitrous oxide. To date, 102 of these offices have been tested to determine the degree to which dentists and dental personnel are being exposed to nitrous oxide. Seventeen dentists using nitrous oxide did not wish to have their offices tested.

Cohen's studies revealed significant occupational health risks which result from exposure to nitrous oxide. The survey received responses from 30,650 dentists and 30,547 chairside assistants. Two groups of equal size - about 15,000 nitrous oxide users and 15,000 non-users were systematically derived from the initial responses. Statistically significant health effects reported from this study are shown in Table 1.

Based on the information available in 1977, the National Institute for Occupational Safety and Health (NIOSH)[2] recommended that the maximum permissible level of exposure to nitrous oxide should be a Time Weighted Average (TWA) concentration of 25 ppm during the period of administration (where ppm is parts of contaminant per million parts of air).

Two commercially available passive monitors for measuring nitrous oxide exposures are:

1. The Solid State Sensor Monitor (marketed by Porter Instrument Co.). This is about the size and shape of a 35 mm film canister, and is an eight-hour sampler.

TABLE 1

Health Effects to Dentists and Chairside Assistants
in Dental Offices Where Nitrous Oxide is Used

Health Effects	Annual Exposure Time (Hours)	
	Less Than 300	More Than 300
Spontaneous abortion	Significant for dentist's wives and dental assistants	Significant for dentist's wives and dental assistants
Congenital abnormalities	Only significant for children of dental assistants*	Not significant*
Liver disease	Not significant	Significant for dentists and dental assistants
Kidney disease	Only significant for dental assistants	Significant for dentists and dental assistants
Neurologic disease	Significant for dentists and dental assistants	Significant for dentists and dental assistants

*According to Cohen, paternal exposure does not seem to be associated with a higher rate of congenital abnormalities in offspring. Maternal exposures are associated with increased rates of congenital abnormalities in their offspring. However, statistical significance is present only for the group of light users of anesthetics and the two groups (light and heavy) combined.

2. The R. S. Landauer Monitor (not available before the summer of 1982). This is about the size and shape of an ink pen and is a 40-hour sampler.

Both of these monitors are worn by exposed personnel and then returned to the manufacturer for analysis (infra-red).

The United States Air Force evaluated both of these passive monitors in the field and published the results.[3] At nitrous oxide concentrations above 14 ppm, the Solid State Sensor Monitor gave consistently low values. It was also inaccurate at all levels. (A NIOSH study also found the Solid State Sensor Monitor to be unsatisfactory.[4]) On the other hand, the R. S. Landauer Monitor performed satisfactorily. However, the R. S. Landauer Monitor provides a Time Weighted Average (TWA) measurement for a full week, while the NIOSH standard is only for the TWA period during which the nitrous oxide is being administered.

A Miran 1A infra-red analyzer was used exclusively by the DHES to measure nitrous oxide concentrations in Montana.

The NIOSH criteria document on waste anesthetic gases and vapors[2] states that the "direct infrared analysis of nitrous oxide is the most desirable method." The Miran 1A meets these criteria.

The breathing zone concentrations of nitrous oxide in dental operatories in Montana are quite similar to those found by NIOSH[2] in other areas of the United States. With few exceptions, nitrous oxide levels in Montana greatly exceeded the NIOSH recommended standard.

The nitrous oxide data collected in Montana dental operatories are shown in Table 2. The measurements were made in the dentist's or assistant's breathing zones during the administration of nitrous oxide to one patient.

Scavenging systems removed nitrous oxide from around the breathing mask by means of a vacuum system. About 20% of the dentist's offices tested used a scavenging system.

Leaks in nitrous oxide delivery systems were found in 54 dental offices. An average of about two leaks were found in each office. Nineteen of these leaks were repaired during the inspections.

From Table 2, it can be seen that significant reductions in nitrous oxide levels were obtained with scavenging systems. The levels could be reduced further if dentists carefully monitored the administration of the gas.

TABLE 2

Nitrous Oxide Exposure Levels
Measured in Montana Dental Offices

	Average of all levels (ppm)	Range (ppm) High	Low
Dentist's breathing zones (without N_2O scavenging system)	1100	3700	150
Dentist's breathing zones (scavenging system)	460	1800	7
Assistant's breathing zones (without N_2O scavenging system)	790	2800	100
Assistant's breathing zones (scavenging system)	480	1800	7

The NIOSH publication 77-140[2] contains several studies of nitrous oxide exposures in dental operatories. The exposure levels are similar to those found in Montana. A short summary of these data is listed below:

1. Lecky, J. H.: "Anesthetic trace levels in U. S. Hospitals."[5]
   Method of analysis: Gas Chromatography
   Nitrous oxide levels in dental operatories:
   range = 94 to 3000 ppm
   average = 793 ppm

2. Millard, R. I., Corbett, T. H.: "Nitrous oxide concentrations in the dental operatory."[6]
   Method of analysis: Gas Chromatography
   Nitrous oxide levels after 60 minutes:
   dentists = 6767 ppm
   assistants = 5867 ppm

3. Whitcher, C. E., et.al.: "Controls of Occupational Exposure to Nitrous Oxide in the Dental Operatory."[7]
   Method of analysis: Portable Infra-Red
   Nitrous oxide levels:
   Dentists, average exposures = 1100 ppm
   Oral surgeons, average exposures = 1000 ppm

Since nitrous oxide inhaled into the body is essentially unchanged, a few simple calculations reveal how operatory size and duration of nitrous oxide administration affect final concentrations of the anesthetic in an operatory. The model assumes no dilution ventilation, a nitrous oxide flow

rate of 2.0 liters per minute, and complete mixing of nitrous oxide and air. The data from these calculations are presented in Table 3.

TABLE 3

Calculated Nitrous Oxide Concentrations
in Dental Operatories

Time N_2O Administered to Patient	Nitrous Oxide Concentration Operatory Size in Feet	
	8 x 10 x 8	10 x 12 x 8
After 10 minutes	1100 ppm	740 ppm
After 30 minutes	3300 ppm	2200 ppm

From Table 3 it is readily apparent that nitrous oxide concentration in dental operatories can easily exceed the NIOSH-recommended exposure.

Conclusions

According to Dr. Cohen[1], dentists and chairside assistants in essentially all dental offices where nitrous oxide is used are exposed to concentrations of the anesthetic which may adversely affect their health. In addition, female dentists and chairside assistants exposed to nitrous oxide have an increased risk of spontaneous abortion and of bearing children having congenital abnormalities. The wives of exposed dentists also have increased risk of spontaneous abortion.

Nitrous oxide exposures to dentists and chairside assistants can be substantially reduced by the judicious use of the anesthetic. Good work practices and engineering techniques can also be effective in reducing occupational exposures to nitrous oxide.

Recommendations

With present technology it is unlikely that most dentists can reduce their nitrous oxide exposures to meet the NIOSH standard of 25 ppm (TWA basis, during the period of administration). However, most dentists can significantly reduce their exposures with certain abatement techniques. Some recommended abatement techniques are as follows:

I. Use Improved Engineering Techniques.

A. Use scavenging masks (NIOSH recommends a dual layer type of mask.)

B. Use general dilution ventilation to replace a percentage of operatory air with fresh air. (This will result in some heat losses.)

C. Use small fans located so as to blow the nitrous oxide away from the dentist and assistant.

D. Use additional vacuum sources such as the oral vacuum system or aspirator (saliva ejector) which will remove some excess gas.

E. Reduce the nitrous oxide flow rate and concentration as much as possible, while still maintaining the desired sedation level.

II. Reduce the Nitrous Oxide Exposure Time.

A. Use nitrous oxide only on patients for whom it is necessary.

B. Use nitrous oxide only for the time necessary for the injection of the local anesthetic and possibly during drilling, extractions, or other painful interventions.

C. Don't unnecessarily leave a patient on nitrous oxide while working with another patient, particularly if there will be a significant time lapse before you return to the first patient.

III. Use Improved Work Practices.

A. Make periodic leak checks with soap bubble solutions.

B. Instruct patients not to talk, laugh or breathe through their mouth while under nitrous oxide sedation.

C. Use a rubber dam whenever possible.

D. Fit the mask to the patient's face as well as possible.

E. When possible, secure the mask to the patient's face with the attached gas delivery and vacuum tubes.

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